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A multi-model study on the Southern Ocean CO_2 uptake and the role of the biological carbon pump in the 21st century

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The Southern Ocean is one of the key regions for global carbon uptake and it is under discussion how physical changes will alter its CO_2 balance both directly and indirectly through changes in biological production.

Here we analyse a suite of eight RCP8.5 model simulations until 2100 from the MAREMIP and CMIP5 model intercomparison projects on changes in export production and CO_2 uptake. We explore how the counter-acting effects of stronger winds ("SAM signal", less stratification) and global warming (more stratification) affect CO_2 fluxes in different models and different regions of the Southern Ocean.

The models simulate a broad range of responses with no agreement on the dominance of the SAM or global warming signal or on nutrient or light as the dominant drivers for changes in export production. There is agreement on an increase in export production south of 58°S and on a nutrient-driven decrease of export production in the region 30-44°S (global warming signal). Based on a box-model, we can identify the most important drivers for the future CO_2 uptake in the Southern Ocean where the pure increase of atmospheric CO_2 has the largest effect, followed by the enhanced biological production and the larger effect of biological production on CO_2 uptake at higher Revelle factor. The enhanced upwelling of carbon-rich deep water, and the effects of warming on the CO_2 solubility and faster gas-exchange at higher wind-speeds are less important.